Statistical Physics and Computational Complexity

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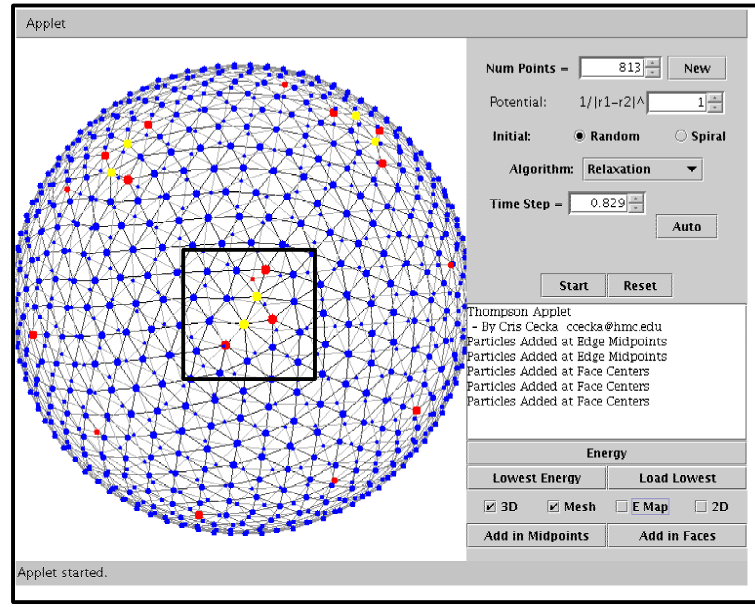
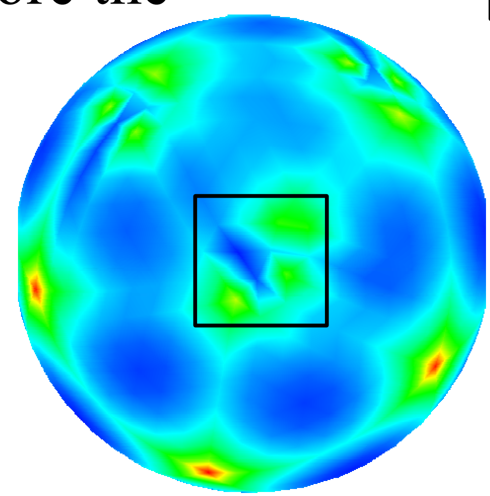
Wrapping a 2D **crystal onto a sphere** creates disclination defects (particles with 5 or 7 neighbors). When the crystal has many particles, dislocation defects appear and distribute the elastic strain, as seen in experiments with colloidal particles on oil droplets. We optimize over arrangements to explore the geometry of these complex assemblies.

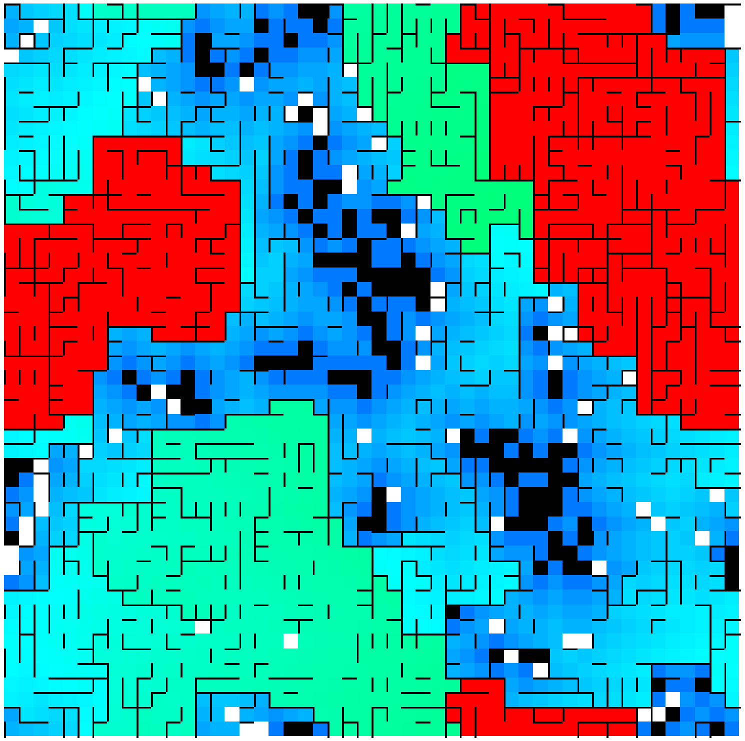


Top: Java simulation of particles on the sphere at **http://www.cs.hmc.edu/~ccecka/SummerResearch/** Red(yellow) circles mark 5-(7-)fold defects. Extra pairs lower the energy.



Right: map of strain energy, where red is high and blue is low.

Optimizing optimization. We explored efficient algorithms for computing ground states in the random-field Ising model, an important model for systems with competing interactions. By visualizing the dynamics of the algorithm and studying the relation between run times and the correlation length, we were able to reduce run times and discover links to reaction-diffusion systems.



Snapshot of the dynamics of the algorithm that finds the ground state of the random-field Ising model. The white squares move down the height gradient (colored high to low) towards black squares and then annihilate. Red regions are solved and inactive.

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Three undergraduate students, James McCollough, Clay Hambrick, Cris Cecka, and a postdoc, Jan Meinke, contributed to this work.

Applets and codes are available at http://azha.phy.syr.edu/comp/